IMPERIAL MINERAL RESOURCES BUREAU.

THE MINERAL INDUSTRY OF THE BRITISH EMPIRE

AND

FOREIGN COUNTRIES.

WAR PERIOD.

FULLER'S EARTH.

(1913–1919.)

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PREFACE.

The following digest of statistical and technical information relative to the production and consumption of fuller's earth will constitute a part of the Annual Volume on the Mineral Resources of the British Empire and Foreign Countries.

In this the first year of publication an effort has been made to fill in, as far as possible, the hiatus due to the war in the publications relating to mining and metallurgical statistics. Labour, health, and safety statistics have been omitted owing to the difficulty involved in procuring reliable information for the war period, but in future issues these statistics will be included in respect of each year.

Resort will also be had to a much greater extent than at present, to graphical representation of statistics of production, consumption, costs and prices.

R. A. S. REDMAYNE,
Chairman of the Governors.

June, 1920.

2, Queen Anne's Gate Buildings,
London, S.W.1.

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GENERAL.

Fuller's earths are clay-like materials, usually non-plastic, and of a greyish, yellowish, greenish or bluish colour. They are essentially complex hydrated silicates of aluminium, with variable amounts of iron oxide, magnesia, lime and alkalies. They are characterized by the fact that they absorb grease, for which reason they have been used by fullers to remove greasy matter from woollen goods, hence the name fuller's earth. They have also the property of absorbing colouring matters, and on that account are largely used for decolorizing oils. It is by the possession of these two affinities for grease and basic colouring matter that fuller's earths are characterized rather than by their chemical analyses.

The chief use of fuller's earths at the present time is for the decolorization and clarification of oils. It is used also as a carrier for certain pigments, as a filler for paper, as an ingredient of some soaps, and for medical and toilet purposes; and it is serviceable in detecting colouring matters in certain food products.

It is worthy of note that the United States removed practically all restrictions on the importation of fuller's earth at the beginning of 1919, as it was thought that the supply of fuller's earth suitable for refining edible oils in the United States was not equal to the demand. The United States earth is quite suitable for use in refining mineral oils, but many consumers appear to be of opinion that it is inferior to imported earth for the purpose of refining edible oils and fats. The requirements of fuller's earth for refining edible oils in the United States are as follows :—(1) That it shall bleach well and that the oil shall not revert to its original colour; (2) that it shall filter well and not cake badly; (3) that it shall leave no permanent disagreeable taste or odour; (4) that the retention of oil in the spent earth shall be small; and (5) that there shall be no spontaneous ignition either in the press or in the waste piles. Many American consumers seem to think that the English earth fulfils these requirements better than does the American earth.

PRODUCTION.

England was formerly the chief producer of fuller's earth, which was exported from the country in large quantities. In recent years fuller's earth has been produced in increasing amounts in the United States of America, whence it has been exported to Europe, notably to Germany. The comparative outputs of the United Kingdom and the United States during the period under review have been as follows :—

Comparative Outputs of Fuller's Earth in United Kingdom and United States.

(In long tons.*)

Year	United Kingdom	United States
1913	31,609	34,459
1914	37,862	36,590
1915	29,298	42,769
1916	29,106	60,555
1917	27,916	64,792
1918	23,290	75,418
1919	24,785	

BRITISH EMPIRE.

United Kingdom.

Fuller's earth has been worked in Great Britain in a number of places, but at the present time the largest works is situated near Reigate, Surrey, where the large quarry owned by the Fuller's Earth Union, Ltd., employs upwards of 45 men. The quarry of the Surrey Fuller's Earth Co., Ltd., at Nutfield in the same district, is next in importance, and there are three mines in active operation at the present time in the same neighbourhood.

The earth is found in strata of Cretaceous age, a section of which, according to Dr. A. H. Cox, shows the following sequence :—

(iii) Clayey glauconitic sands ... ... 20 ft.
(ii) Mottled bluish calcareous sandstones weathering grey, with interbedded seams of fuller's earth ... ... 20-25 ft.
(i) Fuller's earth ... ... 10 ft.

The whole series dips down the hill at an angle of 3 to 5 degrees.

The fuller's earth bed sometimes reaches a thickness of 12 feet, and, as a rule, the upper portion is oxidized to a brownish colour by the action of percolating water, the lower portion being blue.

In Somerset fuller's earth has been worked at a number of places in the vicinity of Bath. It is found overlying the Inferior Oolite and is covered by the Great Oolite. The limestones of the Inferior Oolite contain fuller's earth in the cavities.

The sequence of beds is as follows :—

1. Blue and yellow clay with nodules of indurated marl ... ... 30 feet to 40 feet.
2. Bad fuller's earth ... ... 3 ,, 5 ,,
3. Good ,, ,, ... $2\frac{1}{2}$,, 3 ,,
4. Clay containing beds of bad fuller's earth and layers of nodulized limestone and indurated marl... ... 100 feet.

* The long and short tons referred to in this publication are equivalent to 2,240 lb. and 2,000 lb. respectively.

The two mines now worked are Coombe Hay and Midford. The Bureau is informed on good authority that for use as a clarifier the blue Somerset earth is as good as the Nutfield earth. The Somerset blue earth contains a considerable percentage of calcium carbonate (*see* analysis below).

Other notable deposits of fuller's earth include those of Woburn Sands, in Bedfordshire. The evidence of borings and sinkings indicates that these are co-extensive with the Oxford clay. A superior quality of fuller's earth is procured from the Lower Greensand at Aspley Heath, Bedfordshire. The water thrown out by this formation is very soft and pure, and blocks of the earth have on this account been used for the purpose of purifying water in wells.

The following analyses* showing the composition of various English fuller's earths are taken from the Geological Survey Memoir on the Jurassic Rocks of Great Britain. (Memoirs of the Geological Survey, 1894, Vol. IV , p. 491.)

——	1. Nutfield Earth.	2. Midford Blue Earth.	3. Midford Yellow Earth.	4. Woburn Blue Earth.	5. Woburn Yellow Earth.
Silica	58·66	54·0	59·3	60·00	56·9
Alumina	17·33	18·6	20·8	15·2	15·7
Ferric oxide	7·21	3·9	4·2	7·8	9·5
Ferrous oxide	—	·8	—	1·7	·1
Lime	3·17	7·0	2·5	2·7	2·1
Magnesia	3·26	2·3	1·9	3·3	2·7
Soda	1·63	·7	·6	·2	·3
Potash		1·8	1·7	·6	·7
Carbonic acid	—	3·4	·3	—	—
Loss on Ignition (not including carbonic acid).	8·74	7·2	8·6	8·4	11·9
	100·00	99·7	99·9	99·9	99·9

A bed of clay described as fuller's earth occurs at Rhiwlas, Frongoch, near Bala, North Wales. The beds are about 60 feet thick, and samples analysed by P. G. Sandford show very much the same composition as the earths at Nutfield referred to above. Their appearance, however, is different. The Surrey earth is greasy to the touch, and has a comparatively hard, smooth surface. The Frongoch earth is comparatively soft and friable, dark grey in colour, and dissolves in water to the extent of about four per cent. of its weight. Sandford states that this earth appears to be even better than the Nutfield samples as regards the grease-absorbing properties.

* Analysis (1) is of purified fuller's earth and was made by B. Dyer, July, 1885.

Analyses (2), (3), (4) and (5) were made by J. H. Player, for the Geological Survey in 1890.

The following are analyses of two samples by Sandford of the Frongoch earth* :—

No. 1. Sample A.

	Per cent.			Per cent.
Insoluble Residue ...	78·27 =	Silica		63·25
Al_2O_3	12·95	Fe_2O_3		8·72
Fe_2O_3	0·42	Al_2O_3		6·30
MnO	trace			78·27
CaO	0·82			
MgO	1·65			
SO_3	0·31			
Alkalies	2·02			
Combined H_2O ...	3·56			
	100·0			

No. 2. Sample B.

	Per cent.			Per cent.
Insoluble Residue ...	78·53 =	Silica		57·01
Al_2O_3	2·84	Fe_2O_3		trace
Fe_2O_3	8·50	Al_2O_3		21·52
MnO	trace			78·53
CaO	0·90			
MgO	2·30			
SO_3	0·05			
K_2O, Na_2O	2·12			
Combined H_2O ...	4·76			
	100·00			

Production of Fuller's Earth in the United Kingdom.†
(*In Long Tons.*)

County.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Bedford (from mines)	640	630	590	—	—	—	—
Gloucester (from mines)	—	—	—	—	—	—	495
Somerset (from mines)	3,559	4,256	4,425	5,577	4,109	3,783	3,469
Surrey (from quarries)	27,410	32,976	24,283	23,529	23,807	19,507	20,821
TOTAL	31,609	37,862	29,298	29,106	27,916	23,290	24,785

* Geol. Mag., 1893, p. 160.

† Figures supplied to the Bureau by the Chief Inspector of Mines, Home Office.

*Value of Imports of Fuller's Earth to the United Kingdom.**

Year	Value £
1913	nil
1914	nil
1915	11,649
1916	4,808
1917	2,577
1918	4,038
1919	

*Value of Exports of Fuller's Earth from the United Kingdom.**

Year	Value £
1913	48,882
1914	56,451
1915	47,203
1916	44,427
1917	49,949
1918	53,789
1919	

India.†

The statistics of Indian fuller's earth and similar clays are incomplete. The mineral is probably obtained in small quantities at numerous localities. It is used for the washing of clothes, and constitutes the principal part of the various edible earths which are sold in the bazaars. The earth-eating habit is prevalent throughout India, Burma and the Shan States.

A table is given below showing the annual production of fuller's earth at Katni, in the Jubbulpore district of the Central Provinces, where it occurs in the Lower Vindhyan Series.

The average annual output for the five years 1914 to 1918 was 196 tons.

A form of fuller's earth known as " multani-matti " is also worked in the States of Bikanir and Jaiselmer in Rajputana. In 1913 a production of 1,000 tons was returned for Marwar in Rajputana.

Outputs of 30 and 52 tons of fuller's earth in the years 1911 and 1912 respectively are recorded from the Anantapur district of Madras.

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* Annual Statement of the Trade of the United Kingdom.

† Records of the Geological Survey of India. Annual Report of the Chief Inspector of Mines in India.

Production of Fuller's Earth from a Limestone Mine at Jubbulpore, Central Provinces, India.

Year.	Quantity (long tons).
1913	103
1914	109
1915	139
1916	179
1917	334
1918	218
1919	

Australia.*

A deposit of fuller's earth of considerable size occurs in the Permo-carboniferous coal measures at Wingen, New South Wales. The composition of the earth is as follows :—

Silica	50·61
Alumina	19·35
Ferric oxide	3·55
Lime	1·37
Magnesia	3·24
Potash	·92
Soda	·47
Phosphoric anhydride	trace
Moisture	13·73
Combined water	6·45
	99·69

The only outputs recorded for the period under review are 110 tons and 20 tons, for 1916 and 1917 respectively, from the Narrabri Division.

FOREIGN COUNTRIES.

United States.†

Deposits of fuller's earth have been found in a number of States, including Florida, Georgia, Alabama, Arkansas, Colorado, New York, South Dakota, California, South Carolina and Massachusetts. At first it was entirely used for " fulling " or taking grease from woollen goods, but owing to the cheapness of good soap, this use has almost wholly ceased.

Fuller's earth was discovered in Arkansas in 1891 and is still mined at Benton. Later it was found at Quincy, Florida, and the deposits in this neighbourhood have since furnished all the fuller's earth required for the refining of mineral oils throughout

* Min. Res., N.S.W., by E. F. Pittman. Ann. Reps. Dept. Mines, N.S.W.

† Ann. Reps. Min. Res., U.S.A. Bull. No. 71, U.S.A., Bur. of Mines. Foreign Commerce and Navigation of the United States (Annual).

the States. These earths have not, however, been much used for bleaching fats and vegetable oils, whilst the Arkansas earth is used wholly for edible oils.

With the exception of the Arkansas deposits all the known deposits of fuller's earth in the United States are of sedimentary origin and occur under the same conditions as any clay beds. The Massachusetts deposit is a glacial silt and is the only known glacial silt to be so classified. It is mined at Lancaster and the earth is used wholly in the place of alkali to remove surplus dye from woollen goods. The Arkansas fuller's earth is unique in that it occurs in the form of veins or dykes. Its formation is attributed to the alteration of basaltic dykes.

The deposits are situated about seven miles south of Benton. There are numerous dykes, some of which have been mined, one to a depth of 140 feet. The dip of the dykes varies from 45° to almost 90°.

The Florida deposits are mainly in Gadsden County, near Quincy, and the southern Georgia deposits are just across the State boundary from this town.

A section near River Junction, Gadsden County. Florida, is described as follows :—

Surface sands	60 feet.
Clay and fuller's earth	10 ,,
Not exposed, but probably argillaceous sand	17 ,,
Chattahoochoo chalk or limestone with some layers of marl	88 ,,

Analyses of Fuller's Earth of Florida.

Place.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	H_2O.	Moisture.
Hymeson Mine	59·00	15·05	2·95	0·20	3·70	11·40	7·80
McPhaul Mine	58·50	14·30	2·10	1·30	6·50	9·50	7·0
McPhaul Mine	62·85	15·36	2·25	1·39	6·98	10·20	—

In South Dakota, near Fairburn, Custer County, large deposits occur, the section at the mine, beginning at the top, being :—

Micaceous sandy clay	6 feet.
Fuller's earth	9 ,,
Micaceous sandstone	—

Two miles west of Argyle in a shaft sunk 26 feet the following section was obtained :—

Surface pebbles	1 foot.
Sandstone	1½ feet.
Fuller's earth	18 ,,
Clay and earth	2 ,,
Sandstone	5 ,,

The following analyses show the usual composition of the fuller's earths of South Dakota :—

Place.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	H_2O
Bodenner's pit, Fairburn ...	68·23	14·93	3·15	2·93	0·875	6·20
M. Palmiter, Fairburn ...	60·16	10·38	14·868	4·96	1·714	7·20
M. Palmiter, Fairburn ...	56·18	23·23	1·26	5·88	3·29	11·45
D. Henault, Custer City ...	55·45	18·58	3·82	3·40	3·50	8·80
E. J. Riederer, Fairburn ...	58·72	16·90	4·00	4·06	2·56	8·10

These earths are said to bleach as well as the English earths.

In South Carolina there is a very large deposit in Williamsburg County, near Salter's Depôt, one in Dorchester County, near Summerville, and one in the neighbourhood of Sumter, Sumter County.

In California, fuller's earth occurs in Kern and San Bernardino Counties. The beds range from 15 to 50 feet in thickness, and are of Cretaceous, Tertiary, and Pleistocene ages. It has only been mined as yet at Vacaville and Bakersfield.

In Texas deposits have been found at a number of places, such as Summerville, West Point and Burton. The expansion of the petroleum and cotton-seed oil industry in Texas makes the production of fuller's earth of importance.

*Fuller's earth produced and marketed in the United States.**

Year.	Quantity short tons.	Value.	Average price per ton.
		$	$
1913	38,594	369,750	9·58
1914	40,981	403,646	9·85
1915	47,901	489,219	10·21
1916	67,822	706,951	10·42
1917	72,567	772,087	10·64
1918	84,468	1,146,354	13·57
1919			

* U.S. Geol. Surv. Min. Res. Preliminary Report for 1918.

*Fuller's earth imported for consumption to the United States.**

Year.	Unwrought and Unmanufactured.			Wrought or Manufactured.			Total.		
	Quantity.	Value.	Average Price per ton.	Quantity.	Value.	Average Price per ton.	Quantity.	Value.	Average Price per ton.
	Short tons.	$	$	Short tons.	$	$	Short tons.	$	$
1913	1,916	12,344	6·44	16,712	133,657	8·00	18,628	146,001	7·84
1914	1,468	9,283	6·32	23,509	185,800	7·90	24,977	195,083	7·81
1915	850	5,176	6·09	18,591	147,317	7·92	19,441	152,493	7·84
1916	1,132	7,742	6·84	15,669	131,922	8·42	16,801	139,664	8·31
1917	1,441	11,718	8·13	15,553	164,699	10·58	16,994	176,417	10·38
1918	900	10,502	11·67	11,707	155,033	13·24	12,607	165,535	13·13
1919									

* U.S. Geol. Surv. Min. Res.

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APPENDIX.

NOTE ON THE NATURE OF FULLER'S EARTH.

The Imperial Mineral Resources Bureau has received communications from Dr. E. F. Armstrong and Dr. J. W. Evans pointing out that the nature and properties of fuller's earth require investigation. Little or nothing appears to be known of any relationship that may exist between the chemical or mineral composition of the earth and its peculiar physical properties, and it seems desirable that this possible relationship should be carefully investigated.

At a recent meeting of the Chemical Industries Committee of the Bureau this desirability of research into the nature and properties of fuller's earth was discussed, and Sir Herbert Jackson suggested that it would be useful to have a more detailed statement as to the nature of fuller's earth than the one given on page 4 of this report, even if such a statement involved speculative views. The following brief statement is therefore put forward, not in any dogmatic spirit, but as a stimulus to research on this problem.

Fuller's earth, like ordinary rock clays, is of a somewhat indefinite composition. When examined under the microscope it is seen to consist partly of amorphous and partly of crystalline matter. The amorphous base of fuller's earth is probably closely similar to ordinary rock clay in composition, consisting essentially of hydrated silicate of aluminium with incompletely decomposed mineral matter containing alkalies and other bases. The crystalline matter present in fuller's earth includes various mineral substances, some of which are clearly detrital.

The chemical composition of fuller's earth suggests that the colour of the fresh earth may be due to disseminated iron silicate of a glauconitic character, the oxidation of which would explain the change of colour in fuller's earth on weathering. Glauconite is a hydrated silicate of aluminium, iron and potash.

The crystalline matters present in fuller's earth probably include free silica and silicates, together with small amounts of the heavier detrital minerals such as zircon. A considerable amount of calcite may be present in some cases, and various other crystalline products such as barytes and zinc-blende which, though perhaps incorporated in some way during deposition, probably owe their present condition to infiltration and other changes since the fuller's earth was deposited.

The origin of fuller's earth is not yet understood. Dr. A. H. Cox, who has studied this subject recently on the petrological side, states that, when examined microscopically, fuller's earth presents certain features that at once distinguish it from ordinary detrital clays, and he is of the opinion that it represents a true precipitate, by which he presumably means a chemical precipitate. He thinks this accounts for its occurrence as an extremely uniform and fine-grained deposit interbedded with coarse sands, and points out that in the occurrences known in this country at different stratigraphical horizons, the fuller's earth is always associated with sandy limestones or highly calcareous sandstones. On the subject of the origin of fuller's earth, however, there is much room for difference of opinion, and it seems not improbable that fuller's earth will be ultimately proved to have had a detrital origin for the most part. The possibility should be kept in mind that it may consist of secondary (*i.e.*, redistributed) rather than primary detritus. It might be suggested that the comparison of fuller's earth chemically, petrologically, and otherwise,

with certain other blue clays and muds, including those now being deposited around our coasts, would prove instructive and would perhaps throw some light on its exact nature and origin.

The problems connected with fuller's earth are attractive and many-sided, and deserve attention as the object of purely scientific research. They are difficult problems, and if they could be solved, the results would undoubtedly be of economic importance. The successful prosecution of such research will require the co-operation of the chemist, the physicist, and petrologist, since it is desirable that the mineralogical and chemical composition, physical properties, and technical uses should all be ascertained on each of the samples examined.

T. C.